Project	IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>
Title	A compactEnhanced MAP message IEs to provide a virtual multi-frame structure for a periodic fixed bandwidth assignment scheme.
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Re:	802.16REVe/D5 Sponsor Ballot
Abstract	This contribution introduces a new compact-map type to provide a virtual multi-frame structure for periodic resource allocation.
Purpose	Discuss and adopt the suggestion into P802.16e/D6.
Notice	

EnhancedA compact MAP message IEsmessage to provide a virtual multi-frame structure for a periodic fixed bandwidth assignment scheme

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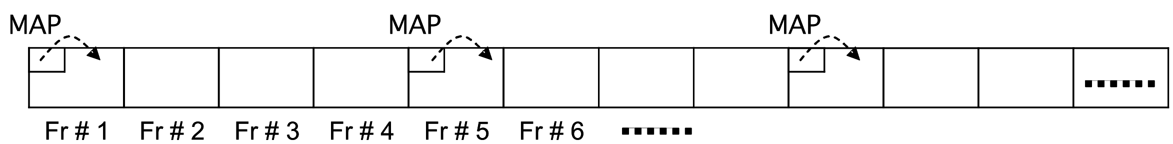
1. Document Goal

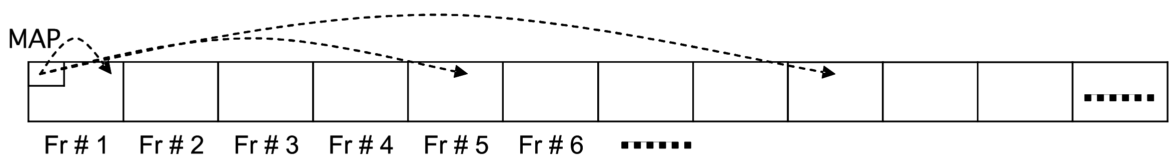
This document introduces a new type of compact MAP message to facilitate a periodic resource allocation for the UGS-type of service classes, e.g., VoIP. By defining a virtual multi-frame structure, it shall allow for designating the fixed bandwidth assignment frames in an efficient manner. The objective of the current proposal is to reduce the MAP overhead inherent to the current specification, especially when the number of connections increases.

2. Problem

In the current specification, MAP message is required for dynamic bandwidth allocation, i.e., MAP message required for every frame in which the bandwidth is allocated. In general, it may suffer from an enormous overhead associated with the dynamic bandwidth allocation, especially when the number of connections increases. In particular, when a payload size is relatively small, the overhead problem becomes critical. One particular example is a VoIP service, which generates a small payload in a periodic manner, e.g., 20 byte payload generated every 20ms for G.729 codec. In fact, any type of CBR service is faced with the same problem. As all these types of services require a periodic resource allocation, it may not be necessary to resort to the MAP message in every frame. In other words, it is sufficient to notify an MSS of the bandwidth allocation information only once with the corresponding allocation period in terms of the number of frames. The same resource allocation information is used implicitly for the later frames until the session is over. Figure 1 illustrates the dynamic bandwidth assignment and fixed bandwidth assignment when a bandwidth reservation is required for every 4 frames. The obvious advantage of the fixed bandwidth assignment is that only a single MAP message is needed at the beginning of each session, which eliminates an overhead associated with individual MAP every time a bandwidth is reserved. In case that a channel condition is changed to incur the different PHY mode during a session, however, old MAP information is not valid any more, which makes the fixed assignment useless. To remedy this problem, new allocation information for the MSS subject to a PHY mode change can be included in the subsequent MAP message. Therefore, all MSS's subject to the fixed assignment still have to listen to all MAP messages in every frame, which makes sure that a new allocation is addressed. We note that the fixed bandwidth allocation can be implemented without changing the current specification, simply because the compact MAP identifies every CID allocated in the corresponding frame. As long as no allocation information for the MSS subject to the fixed assignment is found in the MAP message in a frame, it simply assumes that the previous allocation is still valid. In other words, the fixed assignment is maintained until a channel condition changes.



(a) Dynamic Assignment



(b) Fixed Assignment

Fig 1. Dynamic Bandwidth Reservation Schemes for Periodic Allocation

In spite of the advantage of fixed assignment, its implementation is not straightforward in practice. The current specification addresses the bandwidth assignment in terms of the number of subchannels in the order of CID that appears in the MAP. In such a format, a region specified for the fixed assignment can be overwritten by another MSS, which makes the fixed assignment useless.

3. The Proposed Approach

To remedy the overwritten problem discussed in the previous section, we propose to use the *periodic* fixed bandwidth assignment scheme, which allows for refreshing the MAP message in a periodic manner. For a given period, a special update MAP message is used to announce that a currently designated region reserved for the fixed assignment must not be overwritten by all other MSS's while updating a change in the PHY mode if necessary. Whenever an MSS listens to the update MAP message transmitted in a given period, it finds the fixed assignment region, which must not be used by itself during that period.

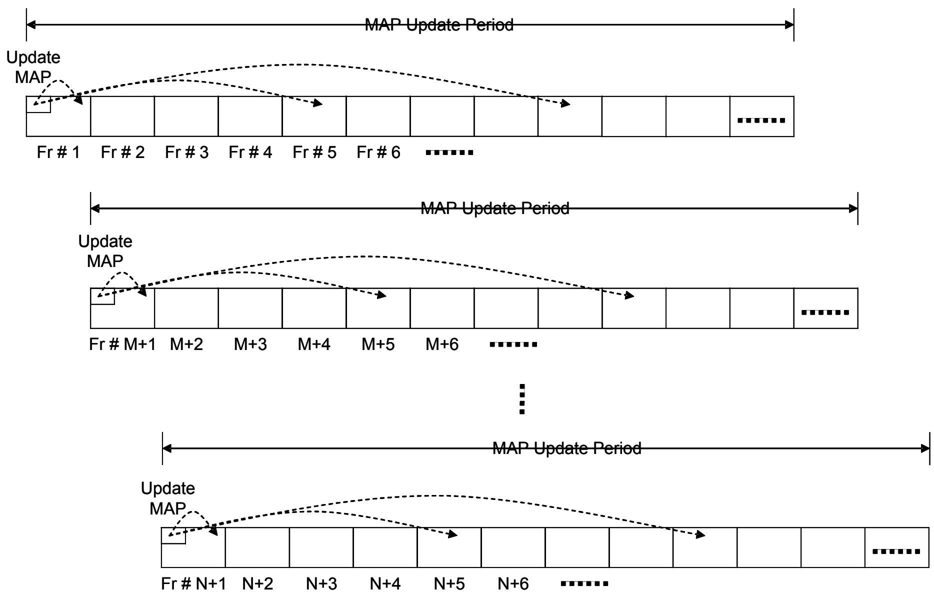
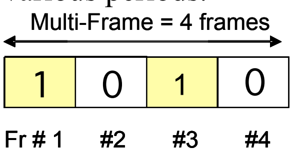


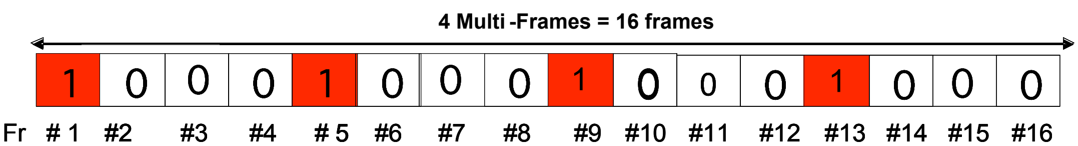
Fig 2. Periodic Fixed Bandwidth Assignment

Given a MAP update period for the fixed assignment, the update MAP message at the beginning of each period must indicate a specific frame in which a fixed assignment is applied per connection (See Figure 2). One possible way of indicating the frames of the fixed assignment is to use a bit map. In this case, as the update period increases, a size of bit map becomes excessive. In this contribution, we consider a notion of a multi-frame structure, which can be implemented in a virtual sense. As shown in Figure 3, the update period is given by a multiple of 4 frames, i.e., 4 frames (1 multi-frame), 8 frames (2 multi-frames), 16 frames (4 multi-frames), 32 frames (8 multi-frames), 64 frames (16 multi-frames), and 128 frames (32 multi-frames), which can be represented by a 3-bit long update period field in a MAP message. Once the update period is given, the fixed assignment is specified by the 3-bit long fixed assignment period filed and 3-bit long frame start offset field in a MAP message.
To accommodate the virtual frame structure addressed in the above, a new type of compact DL-MAP message is introduced, i.e., DL_MAP Type = 7 in Compact_DL-MAP_IE.

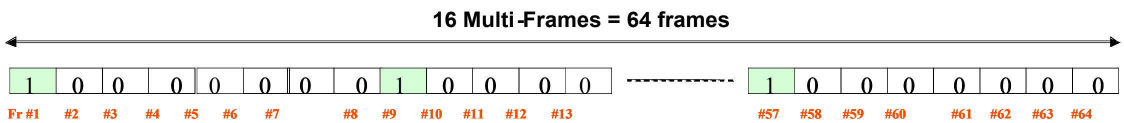
The difference from the existing compact DL-MAP is to include the update period and the fixed assignment period and start frame offset of assignment. Note that the fixed allocation period can take an integer in $[1,2^n]$, $n = 1,2,3,..,7$ under the current proposal. Figure 3 illustrates the proposed structure for the fixed assignment with various periods.



(a) Illustration for Fixed Assignment with a Period of 2 Frames for the Multi-Frame length



(b) Illustration for Fixed Assignment with a Period of 4 Frames for the 4 Multi-Frame length



(c) Illustration for Fixed Assignment with a Period of 8 Frames for the 16 Multi-Frame length

Fig 3. Illustration for Fixed Assignment

4. Specific Text Changes for Compact MAP in the Standard

Remedy 1:

In page 44, Line 10, section 6.3.2.3.43.6.9, add following section.

[Add new section 6.3.2.3.43.6.9 as follows:]

6.3.2.3.43.6.9 Compact DL-MAP IE format for multi-frame allocation extension

The format of Compact DL-MAP IE for multi-frame allocation extension is presented in Table T1.

When the IE appears after Compact DL-MAP IE for Band AMC, BS allocates the region specified by the Compact DL-MAP IE for Band AMC IE to the specified SS periodically with additional MAP message. A SS may negotiate the fixed allocation capability using SBC message.
BS may allocate a band to multiple SS using multi-frame allocation. A band, however, can't contain both multi-frame allocation burst and normal allocation burst in same frame.

Table T1 — Compact DL-MAP IE for multi-frame allocation extension

Syntax	Size	Notes
Compact_DL-MAP_IE () {		
MAP Type = 7	3 bits	Extension type
Sub Type = 3	5 bits	Multi-frame allocation sub type
Length = 1	4 bits	
Multi-frame duration	3 bits	000: Infinite 001: 4 frames 010: 8 frame 011: 16 frames 100: 32 frame 101: 64 frames 110: 128 frames 111: De-allocation The allocation ends at the update-type frames.
Multi-frame Period (=p)	2 bits	The subchannels are allocated by the period of every 2^p frames.
}		

In page 44, Line 10, section 6.3.2.3.43.6.9, add following section..

[Add new section 6.3.2.3.43.7.9 as follows:]

6.3.2.3.43.7.9 Compact UL-MAP IE format for multi-frame allocation extension

The format of Compact UL-MAP IE for multi-frame allocation extension is presented in Table T1.
When the IE appears after Compact UL-MAP IE for Band AMC, the BS allocates the region specified by the Compact UL-MAP IE for Band AMC IE to the specified SS periodically with additional MAP message.

Table T1 — Compact UL-MAP IE for multi-frame allocation extension

Syntax	Size	Notes
Compact_UL-MAP_IE () {		
MAP Type = 7	3 bits	Extension type
Sub Type = 3	5 bits	Multi-frame allocation sub type
Length = 1	4 bits	
Multi-frame duration	3 bits	000: Infinite 001: 4 frames 010: 8 frame 011: 16 frames 100: 32 frame 101: 64 frames 110: 128 frames 111: De-allocation The allocation ends at the update-type frames.
Multi-frame Period (=p)	2 bits	The subchannels are allocated by the period of every 2^p frames.
}		

In page 293, Line 28, change following text.

[Add new section 11.8.3.7.6 as follows:]
11.8.3.7.6 OFDMA MAP Capability
This field indicates the different MAP options supported by a WirelessMAN-OFDMA PHY. This field is not used for other PHY specifications. A bit value of 0 indicates "not supported" while 1 indicates "supported."

Type	Length	Value	Scope
155	1	bit #0: H-ARQ MAP Capability bit #1-2 reserved bit #3: Multi-frame allocation capability bit #14-7: reserved	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

4. Specific Text Changes for Normal DL/UL-MAP in the Standard

Remedy 1:
We introduce a new IE called the Dedicated resource allocation IE for DL-MAP

[*Insert the following new Section 8.4.5.3.19*]

8.4.5.3.19 Dedicated resource allocation IE

This DL MAP IE is used for BS to allocate dedicate DL resource to one or more MSSes and to de-allocate or modify an existing allocation. When the DCD change count changes in the DL-MAP, the MSS shall reset all existing dedicated resource allocation.

Table 284j – Dedicated resource allocation IE format.

Syntax	Size	Notes
Dedicated_resource_allocation_IE() {		
Extended DIUC	4 bits	0x09
Length	4 bits	Length in bytes
Num_Allocations	4 bits	Number of allocations in this IE
For (i=0; i<Num_Allocations;i++)		
{		
CID	16 bits	
Allocation Duration(d)	3 bits	The allocation is valid for 10 x 2^d frames where the dedicated allocation appears starting from the first frame. If d ==0b000, the dedicated allocation is de-allocated If d == 0b111, the dedicated resource shall be valid until the BS commands to de-allocate the dedicated allocation
If (d!=000)		
{		
DIUC	4 bits	
OFDMA_symbol_offset	8 bits	
Subchannel_offset	6 bits	
Boosting	3 bits	
No. OFDMA symbols	8 bits	
No. subchannels	6 bits	
Repetition Coding Indication	2 bits	
Period(p)	3 bits	The DL resource region is dedicated to a MSS in every 2^pth frame
Frame_offset	3 bits	The first frame where the allocation takes effect is the frame with 3 LSB frame number the same as the Frame offset.
Dedicated_CH_ID	2 bits	Channel ID assigned to this allocation
}		
else		
{		
Dedicated_CH_ID	2 bits	
}		
}		
Padding	*variable*	
}		

Num_Allocations
Number of allocations in this IE
Allocation Duration(d)
The allocation is valid for 10 x 2^d frames starting from the next frame
If d ==0b000, the dedicated allocation is de-allocated
If d == 0b111, the dedicated resource shall be valid until the BS commands to de-allocate the dedicated allocation
Period(p)
The DL resource region is dedicated to a MSS in every 2^pth frame

Dedicated_CH_ID
The channel ID assigned to this allocation.

Remedy 2:
We introduce a new IE called the Dedicated resource allocation IE for UL-MAP

[*Insert the following new Section 8.4.5.4.23*]

8.4.5.4.23 Dedicated resource allocation IE

This UL MAP IE is used for BS to allocate dedicate UL resource to one or more MSSes and to de-allocation or modify an existing allocation. The dedicated UL resource is marked by the absolute OFDMA subchannel and symbol offsets with respect to the beginning of the frame, as defined in the UL-MAP in which the Dedicated_resource_allocation_IE is received. When the UCD change count changes in the UL-MAP, the MSS shall reset all existing dedicated resource allocation.

Table 298j – Dedicated resource allocation IE format.

Syntax	Size	Notes
Dedicated_resource_allocation_IE() {		
Extended UIUC	4 bits	0x09
Length	4 bits	Length in bytes
Num_Allocations	4 bits	Number of allocations in this IE
For (i=0; i<Num_Allocations;i++)		

{		
CID	16 bits	
Allocation Duration(d)	3 bits	The allocation is valid for 10 x 2^d frames where the dedicated allocation appears starting from the first frame. If d ==0b000, the dedicated allocation is de-allocated If d == 0b111, the dedicated resource shall be valid until the BS commands to de-allocate the dedicated allocation
If (d!=000)		
{		
UIUC	4 bits	
Duration	10 bits	In OFDMA slot
Repetition Coding Indication	2 bits	
Period(p)	3 bits	The UL resource region is dedicated to a MSS in every 2^pth frame
Frame_offset	3 bits	The first frame where the allocation takes effect is the frame with 3 LSB frame number the same as the Frame offset.
Dedicated_CH_ID	2 bit	Channel ID assigned to this allocation
}		
else		
{		
Dedicated_CH_ID	2 bits	
}		
}		
Padding	variable	
}		

Num_Allocations

Number of allocations in this IE

Allocation Duration(d)

The allocation is valid for 10 x 2^d frames starting from the next frame

If d ==0b000, the dedicated allocation is de-allocated

If d == 0b111, the dedicated resource shall be valid until the BS commands to de-allocate the dedicated allocation

Period(p)

The UL resource region is dedicated to a MSS in every 2^pth frame

Dedicated_CH_ID

The channel ID assigned to this allocation.

Remedy 3:

We introduce a new IE called the Slot_Offset_IE for UL burst allocation. The Slot_Offset_IE defines the offset with respect to the beginning of the current frame, at which the UL burst allocation by subsequent IEs following this IE will begin.

[*Insert the following new Section 8.4.5.4.24*]

8.4.5.4.24 Slot_Offset_IE

The Slot_Offset_IE is used by the BS to indicate the offset with respect to the beginning of the current zone, at which the UL burst allocation by subsequent IEs following this IE will be begin.

Table 298k – Slot Offset IE

Syntax	Size	Notes
Slot_Offset_IE() {		
Extended DIUC	4 bits	0x?
Length	4 bits	Length in bytes
Slot offset	11 bits	the offset with respect to the beginning of the current zone, at which the UL burst allocation by subsequent IEs following this IE will be begin
}		

5. Simulation Results

Table 1 illustrates the MAP size reduced by the proposed approach for band AMC MAP IE when bandwidth is periodically allocated every 4 frames for N MSS's. While the MAP IE is generated at a rate of N MAP IE's/4 frames with the dynamic assignment, we assume that the MAP IE is updated at a period of 128 frames, i.e., MAP IE generation rate of N MAP IE's/128 frames. Assuming that No. band = 1 and N = 70, the existing MAP IE incurs an overhead of 16% for a frame structure with DL:UL = 24:12, while it can be reduced to about 4% with the proposed MAP IE. In general, the overhead reduction increases with the number of MSS's.

Table 1. Comparison of MAP size for the existing and proposed MAP IE: Band AMC subchannel MAP IE

	Existing MAP IE	Proposed MAP IE
MAP size: UL+ DL (A)	136 + 16 * No. band	148 + 16 * No. band
MAP IE Rate (B)	N MAP IE's / 4 frames	N MAP IE's / 128 frame
MAP Size (bits)/frame: (A) * (B)	(136 + 16 * No. band) * N bits / 4 frames	(148 + 16 * No. band) * N bits / 128 frames

For the simulation of the proposed scheme, we made the system-level simulator based on IEEE 802.16d/d5. It is the TDD-OFDMA system with 10MHz bandwidth, total 1024 subcarriers, and a frame structure with DL:UL = 24:12.

We consider a multi-cell structure of 19 cells with 3 sectors, each with 1 km radius. We assume that all MSS's are uniformly distributed in each cell. Data rate for each MSS is determined by the AMC scheme, following the SINR requirement identified by a link-level simulation. Using the COST-231 model for a path loss, i.e., for BS height of 32m and MS height of 1.5m, the loss at distance *d* [km] is given as follows [4]: .

Log-normal shadowing is considered for a large-scale fading model, i.e., shadowing is modeled by , where z_k is a Gaussian random variable ~ N(0,1) and δ = 8 dB. Furthermore, we assume that inter-cell interference is fully loaded, i.e., all subcarriers of each subcarriers are all used. Furthermore, we assume the error-free transmission, i.e., no ARQ protocol invoked. In table 2, we show the simulation parameters.

Table 2. Simulation Parameters

Parameter	Value
	2.3 GHz
Bandwidth	10 MHz
Duplex	TDD
Number of used subcarriers	768
Numbers of Used subchannels	DL : 384 (= 768 * 24 Symbol / 48) UL : 192 (= 768 * 12 Symbol / 48)
Modulation	DL : QPSK, 16-QAM, 64-QAM UL : QPSK, 16-QAM
Chanel Code	Convolutional Turbo Code

<table>
<tr><td colspan="3">Multiple Access</td><td>OFDMA</td></tr>
<tr><td colspan="3">BS Tx</td><td>20 watts</td></tr>
<tr><td colspan="3">Cell structure</td><td>19 Cells / Wrap around structure</td></tr>
<tr><td colspan="3">Antenna Pattern</td><td>3 sectors</td></tr>
<tr><td colspan="3">Mobile Velocity</td><td>60km/h</td></tr>
<tr><td colspan="3">Scheduling</td><td>Proposed scheme</td></tr>
<tr><td rowspan="4">Channel Model</td><td colspan="2">Path loss model</td><td>COST-231</td></tr>
<tr><td rowspan="2">shadow fading Model</td><td>Standard deviation for</td><td>8dB</td></tr>
<tr><td>Shadow fading correlation distance</td><td>50m</td></tr>
<tr><td colspan="2">Multi path Fading</td><td>ITU-T R Multi-Path Channel Model
- Vehicle A</td></tr>
</table>

We consider three different types of traffic sources, i.e., voice, Ethernet, and video sources. Each of these traffic sources are characterized by the parameters shown in Table 3. For a video source, we use the video streaming traffic in [3]. The voice and video traffic is subject to delay constraints. For a voice source, both downlink and uplink is considered. In the current analysis, the highest priority is given to the voice traffic, i.e., bandwidth scheduled for them ahead of the other traffic classes. The remaining resource is allocated for video real-time traffic. Finally, the ethernet traffic is served only with the remaining resource. To decide which connection to serve among the same traffic class, the proportional fairness (PF) scheduling algorithm is applied. The proposed fixed allocation scheme is applied just at voice and video traffic and is not applied at Ethernet traffic. We consider the just diversity channel MAP in the result of MAP symbol overhead ratio, because using the only diversity subchannel.

Table 4. Traffic Model Parameters

<table>
<tr><th></th><th>Voice</th><th>Video</th><th>Ethernet</th></tr>
<tr><td>Arrival rate</td><td rowspan="2">Constant 16 kbps</td><td>10 fps</td><td>Pareto (λ =75 packtes/sec)</td></tr>
<tr><td>Packet length</td><td>Data rate : 32 kbps</td><td>μ = 2800 bits/packet</td></tr>
<tr><td>Max delay</td><td>0.04 sec</td><td>-</td><td>-</td></tr>
</table>

We simulated when fixed allocation scheme is not used and when fixed allocation scheme is used by the update period with 128, 64, and 16 frames. In Figure 4, if the fixed allocation scheme is used, the map overhead symbol ratio of those schemes is much lower than that of general MAP allocation scheme. The MAP overhead symbol ratio of general MAP allocation scheme is about 14 ~ 18%. The MAP overhead symbol ratio of the proposed fixed allocation scheme is about 1 ~ 4%. Therefore, the gap of MAP symbol ratio between two schemes is about 13 ~ 16%.

In Figure 5, if the fixed allocation scheme is used, the system throughput of those schemes is much higher than that of general MAP allocation scheme. The maximal throughput using the proposed fixed allocation scheme is about 2.7Mbps. But, the maximal throughput using the general allocation scheme is about 2Mbps. Therefore, the gap of throughput between two schemes is about 30%. After all, decreasing the total amount of MAPs, we will increase the system throughput. According to the update period, the throughput and MAP overhead symbol ratio are similar. Because this simulation uses the only diversity channel MAP, the total amount of the MAP symbol using both 128 and 16 update period is similar and those throughput is similar, too. In Figure 6, we show the throughput according to the allocation period. The lager the allocation period is, the bigger the throughput is. Instead of increasing the throughput, the packet drop ratio of the real-time traffic will somewhat increase.

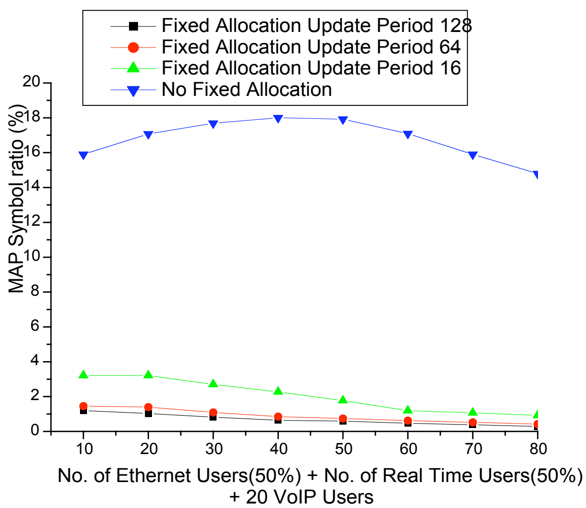


Fig 4. Average MAP symbol ratio

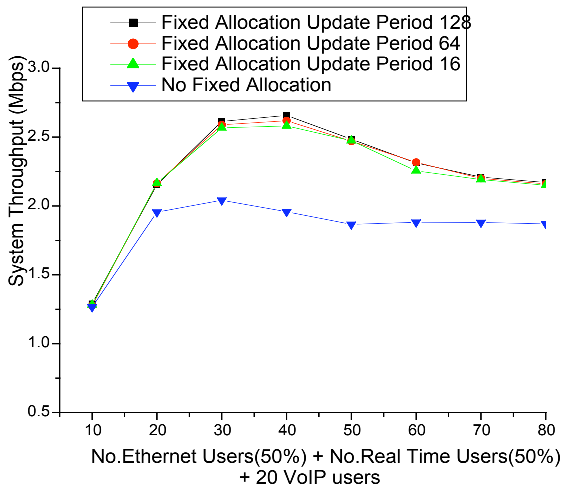


Fig 5. Average throughput

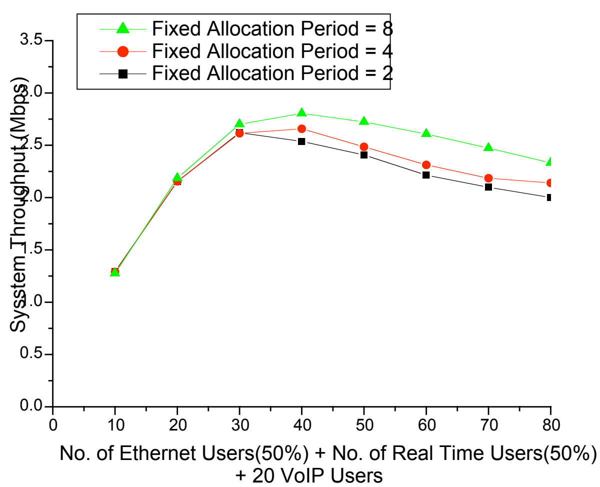


Fig 6. Average throughput by fixed allocation period

6. References

[1] IEEE P802.16e/D3-2004 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Band.

[2] IEEE P802.16-REVd/D5-2004 Air Interface for Fixed Broadband Wireless Access Systems

[3] 3GPP-2, "1xEV-DV Evaluation Methodology Addendum (V6)," July 25, 2001.